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ABSTRACT

Described is the development and use of a scheme for probing arguments in defense of instructional objectives in science education. The perspective used in the development of the scheme is derived from a consideration of science curriculum as a practical enterprise, in the Aristotelian sense. Such a perspective sees curriculum action as the product of a choice among alternatives; in this case, among alternative sets of objectives. The conceptual foundation of the scheme draws upon Gauthier's analysis of practical reasoning and advice. It is shown that a prescriptive argument must involve premises of two types: the first embodies a value position that characterizes some state as being worthwhile or desirable; the second premise is a statement of fact concerning the attributes of the situation. Examples are included of the application of the scheme to science curriculum guidelines and to statements encountered in science curriculum project materials currently used in North America. (MH)

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ANALYZING ARGUMENTS FOR OBJECTIVES IN SCIENCE EDUCATION*

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> *[It is] of incalculable importance for the regulation of their conduct, that men should understand the science of life, physical, mental, and social.* [Spencer 1963 (1860), p. 99]
>
> *. . . the chief value of the study of science [is] the training in certain habits which may be characterized as scientific.* [Woodhull 1918, p. 1]
>
> *The aim of education . . . is Life Enrichment through Participation in a Democratic Social Order.* [NSSE 1932, p. 42]
>
> *Science is best taught as a procedure of enquiry.* [AAAS 1964, p. 4]
>
> *The schools should . . . [promote] understanding of the values on which science is everywhere based.* [NEA 1966, p. 15]
>
> *It is certain that all of us must have some understanding of what scientific activity is, how it is carried on, and how it will affect mankind.* [Cotton and Lynch 1968, p. v]
>
> *The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action.* [NSTA 1971, p. 47]
>
> *The search for a new educational order is based on scientific and technological training, one of the essential components of scientific humanism.* [UNESCO 1972, p. 146]

Science teachers, it appears, have never been short of advice about why they should teach science and about what objectives they should be aiming for. The selections reproduced here are but a fraction of those that I suspect could be discovered were one to search the literature systematically. This paper seeks not to add further to such a stack, but to contribute to our understanding of

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the process of analyzing such advice. The research is thus where the action is: teachers must analyze such advice in order to make defensible choices among the many alternative sets of objectives with which they are confronted.

This, then, provides the starting point for the inquiry: that teachers[1] are obliged to make defensible choices from among alternatives. This obligation serves to characterize the problem as belonging to a practical field (in the Aristotelian sense of the word)--here, the field of science curriculum. Schwab (1970) has discussed at some length the significance of Aristotle's distinction between the practical and the theoretic, for the field of curriculum. He points out that whereas the outcome of the theoretic (of which science itself is a clear example) is the development of warranted knowledge, that of the practical is "a decision, a selection and guide to possible action" (p. 3).

The methods of the practical are correspondingly different from those of the theoretic. It is deliberation that is appropriate here rather than the inductive or deductive methods valued in the theoretic disciplines. In curriculum, according to Schwab:

> Deliberation . . . must try to ascertain the relevant facts in the concrete case. It must try to identify the desiderata in the case. It must generate alternative solutions. . . . It must then weigh alternatives . . . and choose, not the right alternative, for there is no such thing, but the best one. [Schwab 1970, p. 36]

A deliberate choice, then, among competing curricular prescriptions involves the identifying of relevant facts and values implicit in the alternatives in order to weigh them against the characteristics of the situation at hand for which the decision is to be made.

Thus the reasoning model that is brought to bear by the practitioner on the problem must be appropriate to the nature of the enterprise. Furthermore, an inquiry seeking to assist the practitioner in resolving such problems must

take the reasoning model into account. For example, an inquiry that sought to develop a scientific needs-assessment instrument in order that appropriate objectives could be deduced, would be entirely inconsistent with the conceptualization of curriculum outlined here. It would deserve the same criticism that Boyd Bode levelled against Franklin Bobbitt over fifty years ago for engaging in similar "scientific" curriculum making. Bode commented:

> Just how Bobbitt expects a scientific analysis to reveal desirable abilities and needs I am quite unable to discover. No scientific analysis known to man can determine the desireability or the need of anything. [Bode 1975(1927), p. 42]

Thus it is necessary, first, to conceptualize clearly what function is served by curriculum prescriptions. Then by means of a logical analysis of that function, one is able to construct a scheme for the analysis and appraisal of curriculum prescriptions. The remaining part of this paper demonstrates such an analysis and development together with a brief demonstration of the scheme's use.

The Nature of Curriculum Prescriptions

Given that the teacher is in the position of having to make defensible curriculum choices, how, then, is one to regard the many prescriptions he is offered, a few examples of which were cited at the outset?

Statements of objectives and arguments mounted in their support are, firstly, communications intended for teachers. They may, of course, be passed on and be used by others--students, school administrators, parents, for example--but it can be reasonably assumed that the prime recipients will be teachers responsible for courses of which the objectives are to form a part. Furthermore, it is expected that the teachers' conduct will be affected by them in some significant way. If the course is to provide students with the means for attaining certain objectives, then it seems reasonable to suppose that the

activities of the teacher will be related in a direct way to the objectives. Thus, although objectives are not explicit instructions to the teacher on what he ought to do, they carry implications for those activities and indirectly, therefore, they constitute advice to the teacher relative to what he should do. Accordingly a set of objectives may be described as a piece of practical advice. David Gauthier (1963), writing on practical advice, states that "good advice rests on valid practical arguments" (p. 26). It would be appropriate, therefore, to examine the characteristics of practical reasoning more closely if a conceptual framework, of use to practitioners, is to be constructed.

Practical Reasoning[2]

The following discussion of practical reasoning as it concerns curriculum decisions draws from Gauthier's (1963) general analysis of the discourse of practical reasoning. He sets the limits to the analysis by directing the reader's attention to the context in which the decision is to be implemented:

> In practice the answer to a practical question must depend, not only on an appeal to a hierarchy of principles, but far more on an appeal to a context of activity, in which the general programme of action is already fixed. Practical reasoning often consists in showing that an action fits into such a context. [p. 3]

He goes on to describe the nature and structure of a piece of practical reasoning. In a practical syllogism, the major premise is one that "characterizes the state of affairs wanted as in some way desirable, worth wanting" (p. 30). Such a premise he describes as having "practical force," and he adds "at least one premiss [sic] with practical force is required in any piece of practical reasoning" (p. 31).

The major premise is thus a statement that embodies the values of

its author; it characterizes what he considers to be worthwhile or desirable. In a curriculum context, such a statement would indicate those "states of mind" considered to be desirable outcomes of an educational program. Statements of this type underlie all arguments supporting instructional objectives. One function of the scheme described in this paper is to facilitate the identification of value positions inherent in curriculum prescriptions.

In addition to the value premises which must be present in a practical argument, there are usually other premises--statements concerning the situation or "context of activity," the capacity of the agent to act, and the possible or probable consequences of his acting in a given way. These additional, situational premises serve to relate the major premise of the argument to its conclusion. They are statements of fact setting limits to the range of options open to the agent. In the case of practical arguments which are curriculum prescriptions, these situational premises specify relevant attributes of the context in which the curriculum is to be implemented. These attributes have been described in terms of the four commonplaces: the teacher, the learners, the subject matter, and the social milieu (see Tyler 1949, ch. 1, for example). The situational premises in curriculum prescriptions are thus typically concerned with these commonplaces. A second function of the scheme is to identify statements of this type in such a way that further scrutiny of them is facilitated. Error in matters of fact, where situational premises are concerned, can then be more readily be detected.

Finally in the practical syllogism there is the conclusion which is a statement of what ought to be done. A curriculum prescription is a statement of what a teacher ought to do--of what his objectives should be. The complete argument may thus be shown in its simplest form as in the following schema of Gauthier:

> Doing x would be desirable (or, would bring about a desirable situation);
> I can do x,
> so I ought to do it. [p. 44]

It was stated earlier that the deliberative process involves the weighing of alternative sets of objectives each with its own supporting argument. Thus, several arguments may be expected, each of the general form described above, but involving activities y, z, and so on. Furthermore, since curriculum prescriptions involve advice to the teacher concerning what he ought to do, the function of deliberation is a comparative appraisal of these pieces of advice.

Appraisal of Advice

In a section entitled "Appraisal of Advice," Gauthier discusses the types of criticism to which both advisors and advice may be subject. Advisors may be criticized for their competence, their sincerity, and their entitlement to advise. This may be a significant issue in some curriculum deliberation, but it is beyond the scope of this paper to examine it further. On what may go wrong with the advice itself, Gauthier writes:

> . . . since advice is based on practical judgement, what may go wrong with it is what may go wrong in establishing a practical judgement. Three failings may be distinguished: mistake with respect to the practical basis or the corresponding premisses with practical force; mistake with respect to the situation, or the other premisses about the situation; erroneus reasoning from premisses to conclusion. [p. 72]

In order to facilitate the comparative appraisal of different pieces of advice, the function of an analytical scheme would be to identify (a) the conclusions of the argument, (b) the premises with practical force, and (c) the situational premises. The task of the deliberation then involves taking the products of this analysis and appraising them in the manner implied by Gauthier's statement cited above. The premises with practical force, containing the value positions, would be compared to the values of the

teacher, the school, and the community--"the context of activity in which the general programme of action is already fixed." The situational premises--the matters of fact--would be examined to determine whether they are indeed matters of fact rather than value, and, if found to be factual, what support exists for them. Finally, the reasoning from premises to conclusions would be open to examination.

Development of the Analytical Scheme

It is the claim of this paper that Gauthier's analysis of practical reasoning provides a means for probing the arguments mounted in support of objectives in science education. Before such arguments can be examined in detail however, a clue structure must be established, based on the forgoing analysis, which will serve as the means for identifying the components of arguments.

The argument structure set out here follows Gauthier's analysis though with terminology modified to reflect the more specific task of probing curriculum arguments. As has been shown already, an argument consists essentially of three components. The major premise--Gauthier's "premiss with practical force"-- is here described as a "normative premise" as it identifies the educational norms or qualities held to be desirable. It indicates the supposed benefit to the student of achieving the objectives being argued for. Statements of such premises (designated, in the analysis that follows, "type A statements") embody the values held by their proponents.

The second component of the argument comprises the minor premise--Gauthier's "situational premiss"--called here "propositional premise." These premises contain references to all relevant aspects of the situation and especially to the teacher, students, subject matter and milieu. Statements of these premises are designated "type B statements" in the analysis.

The conclusion of the argument is, of course, a statement of the objectives to be taught. Such statements are designated here "type C statements." The first phase of the analysis consists of the identification of the three components described. In a given portion of textual material, it may be that not all three components are explicitly laid out. In these circumstances it is necessary to make rational inferences from the existing components as to the nature of the missing one.

The questions that make up this phase of the analytical scheme are thus as follows:

1. WHAT OBJECTIVE IS STATED OR IMPLIED? (type C statement)
2. WHAT NORMATIVE PREMISE IS STATED OR IMPLIED? (type A statement)
3. WHAT PROPOSITIONAL PREMISES ARE STATED OR IMPLIED? (type B statements)

A Sample Analysis : Phase I

A brief illustration will serve both to amplify the procedure described here and to demonstrate the need for a second phase of analysis. For the purpose of the illustration, I have selected a paragraph from the AAAS (1971) policy statement on the objectives of science education. This is reproduced below as it appears in the original but with line numbers added for the convenience of the reader.

Science as Enquiry

> Science is best taught as a procedure of enquiry. Just as reading is a fundamental instrument for exploring whatever may be written, so science is a fundamental instrument for exploring whatever may be tested by observation and experiment. Science is more than a body of facts, a collection of principles, and a set of machines for measurement; it is a structured and directed way of asking and answering questions. It is no mean pedagogical feat to teach a child the facts of science and technology; it is a pedagogical triumph to teach him these

facts in their relation to the procedures of scientific enquiry. And the intellectual gain is far greater than the child's ability to conduct a chemical experiment or to discover some of the characteristics of static electricity. The procedures of scientific enquiry, learned not as a canon of rules but as ways of finding answers, can be applied without limit. The well-taught child will approach human behavior and social structure and the claims of authority with the same spirit of alert skepticism that he adopts toward scientific theories. It is here that the future citizen who will not become a scientist will learn that science is not memory or magic but rather a disciplined form of human curiosity. [p. 4]

The questions of the scheme are used sequentially in the analysis although no explicit reference is made to them. All statements identified as being of types A, B, or C are enclosed in quotation marks, whether they are exact quotations or inferences from the text. Line numbers are provided for reference purposes on each occasion.

The objective for which this paragraph appears to be arguing is clearly stated in lines 1-2. Although the sentence reads like an assertion concerning what <u>is</u> in fact the best way of teaching science, it seems reasonable, given the title of the document, to assume that it is intended to be a statement of the <u>desired</u> objective for science teaching. Accordingly, the type C statement is identified as follows:

"Science should be taught as a procedure of enquiry" (lines 1 - 2).

The <u>normative</u> premise on which this conclusion is based is found at the end of the paragraph in lines 22-30. Again, though presented as propositions, it is evident that the "spirit of alert skepticism" and the knowledge that science is "not memory or magic but rather a disciplined form of human curiosity" are held to be the desirable outcomes accruing to the student who has this experience of science education. These then constitute the type A statements.

The remaining statements of the paragraph serve as logical links between the type A and type C statements already identified. These are the propositional premises (type B statements) and they are listed here:

B1. "Just as reading is a fundamental instrument for exploring whatever may be written, so science is a fundamental instrument for exploring whatever may be tested by observation and experiment." [lines 2-6]

B2. "Science is more than a body of facts, a collection of principles, and a set of machines for measurement; it is a structured and directed way of asking and answering questions." [lines 6-10]

B3. "It is no mean pedagogical feat to teach a child the facts of science and technology; it is a pedagogical triumph to teach him these facts in their relation to the procedures of scientific enquiry." [lines 10-15]

B4. "And the intellectual gain is far greater than the child's ability to conduct a chemical experiment or to discover some of the characteristics of static electricity." [lines 15-19]

B5. "The procedures of scientific enquiry, learned not as a canon of rules but as ways of finding answers, can be applied without limit." [lines 19-22]

At this stage, the function of each part of the text has been identified. The objective is set out, the normative premise shows the desirable outcomes, and the propositional premises are noted. It is not the task of the analyst to criticize the values implicit in the normative premises; this is the function of the deliberation group who have to live with whatever decision is reached. The type B statements however serve the argument as propositions--as matters of fact--and therefore it is entirely proper to scrutinize them further. This is the function of the second phase of the analysis in which the following questions are asked:

1. WHAT VALUE POSITIONS, IF ANY, ARE PRESENT IN THE PROPOSITIONAL PREMISES?

   i.e. Are the statements really matters of fact or are they the products of personal choice?

2. WHAT SUPPORT, IF ANY, IS PROVIDED FOR THE PROPOSITIONAL PREMISES?

   i.e. How do you know that they are true?

If the propositional premises B1 - B5 are now examined using these two questions, the basis of the argument is further clarified.

A Sample Analysis: Phase II

In this paper, the task is not to comment in an exhaustive fashion on the paragraph cited but to demonstrate the use and applicability of the scheme itself. For this reason therefore, two only of the five type B statements are analyzed here.

It may be noted in passing however, that the five type B statements identified in phase I do relate, in varying degrees, to the four commonplaces mentioned earlier. B1 and B2 exclusively involve the subject matter; B3 concerns both teacher and student; B4 relates the subject matter with the student; and B5 concerns the potential of the subject matter for addressing problems and issues in the wider social milieu. Deliberation must ensure that the interests of all four commonplaces are taken fairly into account. It is inappropriate here, however, to criticize the balance as the paragraph is only a short excerpt from within a more extended document.

Statements B2 and B5 have been selected for further analysis.

Statement B2

It is stated here that "science is . . . a structured and directed way of asking and answering questions" (lines 6-10). The question that must be put in this context is "Is this the only way of characterizing science?" Study in the philosophy of science reveals a large number of ways and the answer to this question must be "No." What has occurred here is that one way of characterizing science has been selected (by the authors) and then presented as though it were the way. A value position is therefore embedded in the statement, which may be exposed as follows:

"The most desirable (or most appropriate) way of characterizing science is as a structured and directed way of asking and answering questions."

No support for the statement B2 is provided in the text. This does not, of course, invalidate the statement, but it does mean that the assertion must be taken by the reader on trust, or on the basis of the authority of the authors rather than on the basis of a more rational authority, such as argument and evidence.

Statement B5

This statement concerns the potential of the procedures of scientific enquiry to be applied elsewhere than in a strictly scientific setting. The assertion is that such potential is "without limit" (line 22). Not only is there no support provided for this, it would appear that none is possible. Any suggestion that there are no limits to the applicability of something has implications not only for the present but also for the future; such a suggestion is clearly beyond verification.

More serious than this problem of support is that this statement is most clearly a value assertion on the part of its authors. The limits of scientific enquiry have been the subject of much philosophical writing over many years, and it must therefore be concluded that the statement expresses a valued belief as indicated here:

"We believe (and value the belief) that the procedures of scientific enquiry . . . can be applied without limit."

In such a way, the second phase of the analysis enables the deliberating group to probe more deeply into the value bases of the argument. The final phase of the analysis reflects the third of the ways in which, Gauthier claims, practical arguments can go wrong: "erroneous reasoning from premises to conclusions." It is important to emphasize here that the analyst is not being required to exercise his own value judgement but to use logical criteria for the identification of gaps in the argument. The concern, then, in phase III, is for whether or not the premises, taken together, logically necessitate the

conclusion that is drawn, or whether additional premises are required. This phase of the scheme involves one question:

1. WHAT PREMISES, LOGICALLY NECESSARY FOR THE ARGUMENT, ARE OMITTED?

   i.e. Do the premises provided "add up" to the conclusion?
   If not, what is missing?

A Sample Analysis: Phase III

Given the normative premises identified in phase I together with the conclusion, it would appear that a premise of the following type is logically required:

"Teaching science as a procedure of enquiry is the most effective way of developing a student's spirit of alert skepticism and his knowledge that science is not memory or magic but a disciplined form of human curiosity."

Nowhere in this passage is such a premise or a functionally similar one to be found, either explicitly or implicitly. It must therefore be concluded that it is both necessary and missing. Furthermore, as another type B statement, it may be subjected to the analysis of phase II of the scheme.

Conclusions

The intent of this paper is to demonstrate the conceptualization of a complex problem in science education--the competing prescriptions for teachers to adopt a variety of different objectives. From the conceptualization of such prescriptions as pieces of practical advice, an analytical scheme[4] has been developed, the intention of which is to expose both the logical components and the values embedded in a practical argument. It has also been demonstrated that the scheme may be applied to a real example of a curriculum prescription in science education. The scheme is offered here in the hope that, with further use and refinement, it will be of significant use to teachers faced with a continuing barrage of (sometimes gratuitous) advice concerning what their objectives for science education ought to be.

Notes

1. Here, and throughout the paper, teachers are referred to as the ones responsible for these decisions. In a given situation it may be that an administrator or a curriculum committee and not the teacher is obliged to make decisions concerning the selection of objectives. The use of the term "teachers" here is for convenience only; it should not be regarded as a stipulation of who ought to make such decisions nor an empirical claim concerning who in practice does make them.

2. Gauthier makes the nice distinction between deliberation, " the psychological process by which a person comes to resolve a practical problem," and practical reasoning, "the logical argument in which the steps leading to the resolution are formally set out" (1963, p. 26). In this section of the paper, it is practical reasoning that is the focus of attention.

3. A more extended analysis on a variety of curriculum prescriptions is described elsewhere (Orpwood 1976). The scheme described here is a modified version of the earlier one.

4. For the reader's convenience the complete scheme is reproduced here.

Phase I

1. WHAT OBJECTIVE IS STATED OR IMPLIED?

2. WHAT NORMATIVE PREMISE IS STATED OR IMPLIED?

3. WHAT PROPOSITIONAL PREMISES ARE STATED OR IMPLIED?

Phase II

1. WHAT VALUE POSITIONS, IF ANY, ARE PRESENT IN THE PROPOSITIONAL PREMISES?

2. WHAT SUPPORT, IF ANY, IS PROVIDED FOR THE PROPOSITIONAL PREMISES?

Phase III

1. WHAT PREMISES, LOGICALLY NECESSARY FOR THE ARGUMENT, ARE OMITTED?

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